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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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EXAMINER	
DAHIMENE, MAHMOUD	

ART UNIT	PAPER NUMBER
1792	

MAIL DATE	DELIVERY MODE
04/02/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/562,400	KANNAN ET AL.	
	Examiner	Art Unit	
	MAHMOUD DAHIMENE	1792	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04 March 2009*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-4,9-12 and 14-82* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-4,9-12 and 14-82* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 3/4/2009 has been entered.

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

1. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 1-4, 6-8, 9-10, 63-65, 67-69, 77, 79, 80, 81, 82, are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429) , Steinwandel et al. (US 5,782,085) and Raaijmakers et al. (US 5,460,689).

Regarding claims 1-4, Sorensen discloses a semiconductor processing system wherein a plasma is generated in a toroidal plasma generator, said toroidal plasma generator comprising a gas passage having a gas entrance (120a) and a gas outlet (120b), said gas passage forming a circuitous path (104), citing a coil (200) wound around a part of the gas passage (204) as an option for the toroidal plasma source (paragraph 0046) ,characterized in that said method comprises the steps of supplying a mixed gas of an Ar gas and an NF3 gas. The plasma will dissociate the NF3 gas to produce radicals from the NF3 molecule. Sorensen discloses “in many applications, use of a carrier gas mixed with the precursor gas may be undesirable. This would be particularly true in semiconductor processing chambers that do not use the carrier gas for the substrate processing. For example, argon may be incompatible with many processing chambers. In accordance with one aspect of the present invention, because of the efficient coupling between the primary coil 16 and the secondary winding of the toroidal vessel 18 of the illustrated embodiment, the use of such carrier gasses to help initiate or stabilize the plasma can be reduced or eliminated. Thus, an argon-free flow of activated NF.sub.3 may be provided by the plasma source 12 during both startup and operation.” (paragraph 0043). “For efficient operation, the internal pressure of the toroidal vessel 18 is held at a pressure suitable for the particular application. Typical

pressures are in the range of 0.1 to 20 Torr." (paragraph 0044), this pressure range overlaps applicant's claimed rage of 6.65 to 66.5 Pa (50 to 500 mTorr). Overlapping ranges are held obvious.

It is noted that Sorensen does not expressly disclose a gas mixture containing a specific range of said NF3 gas in argon, and igniting plasma being conducted under a total pressure of 6.65 to 66.5Pa. However, Sorensen discloses "In accordance with one aspect of the present invention, because of the efficient coupling between the primary coil 16 and the secondary winding of the toroidal vessel 18 of the illustrated embodiment, the use of such carrier gasses to help initiate or stabilize the plasma can be reduced or eliminated. Thus, an argon-free flow of activated NF.sub.3 may be provided by the plasma source 12 during both **startup** and operation." (paragraph 0043). **Clearly Sorensen suggests NF3 without argon is harder to ignite than an Ar/NF3 gas mixture**. In addition Selbrede teaches Ar/NF3 gas flow ratio are conventionally known to be variable process parameter varying essentially from 0% to 100%.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include argon in the NF3 gas in any proportions including at least 5 % NF3, or a concentration of 5% or more but not exceeding 45%, or a concentration of 10% or more but not exceeding 45%, or a concentration of 20% or more but not exceeding 45%, in a mixed gas of argon gas and NF3 because any amount of argon would have made plasma ignition

easier according to Sorensen since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art.

One of ordinary skill in the art would have been motivated to use at least 5% NF3 when little fluorine active species are needed in the process, argon being an inert non-reactive carrier gas. It has been held that there is no invention where the difference in proportions is not critical and was ascertained by routine experimentation because the determination of workable ranges is not considered inventive. As to the ignition pressure Sorensen provides a working range of 0.1 to 20 Torr for which, an argon-free or (when argon is acceptable in the process) an argon containing flow of activated NF.sub.3 may be provided by the plasma source 12 during <u>both startup and operation</u>. Applicant did not show unexpected results in generating an ar/NF3 plasma at the claimed gas ratios and pressure range.

Sorensen suggests cleaning method for cleaning a processing vessel evacuated by an evacuating system 56 and coupled with a remote plasma source 18, said remote plasma source comprising a toroidal plasma generator, said toroidal plasma generator comprising a gas passage having a gas entrance 120a and a gas outlet120b, said gas passage forming a circuitous path (figure 1), and a coil would around a part of said gas passage, characterized in that said cleaning method comprises the steps of: forming radicals containing F in said remote plasma source; and supplying said radicals to an interior of said processing vessel 14 and cleaning said interior of said processing vessel by said radicals, said step of forming said radicals comprising the steps of: supplying a mixed gas containing at least 5% of NF3 in an Ar gas to said gas passage as a cleaning

gas with a first pressure in which plasma can ignite and igniting plasma by driving said coil by a high-frequency power.

Selbrede discloses “the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.” (paragraph 0048), including in an NF3/ar mixture (paragraph 0070)(figure 12).

It is noted that neither Selbrede nor Sorensen expressly disclose increasing the gas pressure after ignition of the plasma, However, Selbrede clearly teaches lowering the pressure facilitates plasma ignition. Therefor, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to decrease the pressure in order to facilitate plasma ignition because Selbrede clearly teaches lowering the pressure facilitates plasma ignition, also, it would have been obvious to one of ordinary skill in the art at the time the invention was made to increase the pressure back to the processing pressure after the plasma has been ignited since Steinwandel teaches that reducing pressure for the purpose of plasma ignition is a known plasma ignition scheme. Steinwandel teaches “It is furthermore possible to superimpose **a brief** high-frequency pulse (with a pulse width of about 1 msec) on the stationary excitation field **or to reduce pressure** in order to ignite the plasma (breakdown).” (column 5, line 55). The reference of Steinwandel is not relied on to teach plasma jet processing, but it is relied on to teach that temporarily reducing

pressure or temporarily increasing the excitation field are known methods for facilitating plasma ignition.

One of ordinary skill in the art would have been motivated to ignite the plasma at a lower pressure in order to facilitate plasma ignition as suggested by Steinwandel.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to increase a total pressure of said mixed gas, after plasma ignition has been facilitated with reduced pressure, by increasing the flow in said gas passage to a second pressure while maintaining said plasma, said cleaning step cleaning said interior of said processing vessel at said second pressure because Selbrede teaches the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated.

One of ordinary skill in the art would have been motivated to increase the total pressure of the gas mixture back to the preferred operating processing pressure, after plasma ignition, in order to obtain higher active cleaning species density due to higher pressure which also means higher molecular active density in the processing region.

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant's newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after

establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC's) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3

gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

As to claims 6-8, as discussed above, Selbrede teaches Ar/NF3 gas flow ratio are conventionally known to be variable process parameter varying essentially from 0% to 100%.

As to claims 9-10, it is noted that Sorensen does not expressly disclose changing the gas pressure and flow after plasma ignition as required in the claims.

However, Selbrede discloses “the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.” (paragraph 0048), including in an NF3/ar mixture (paragraph 0070)(figure 12).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to increase pressure after plasma ignition because Selbrede teaches the power required to **ignite and sustain** a plasma in the Remote Plasma Chamber (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.

One of ordinary skill in the art would have been motivated to increase pressure after plasma ignition in order to obtain ignition at the lowest possible power, then adjust the pressure (by increasing it) to the desired process condition. As to the pressure changes and gas flow, Selbrede teaches “FIG. 12 also shows a graph of exemplary remote plasma chamber power as a function of NF.sub.3 addition to a constant Ar carrier gas flow of 1,000 sccm and a process chamber pressure of 1 Torr. The graph shows that when no NF.sub.3 is present in the feed the plasma generator operates at approximately 250 watts. When NF.sub.3 is increased from 10 to 1000 sccm the remote power supply also increases the power supplied to the plasma where a flow of 1,000 sccm requires about 2,700 watts.” (paragraph 0071). Selbrede teaches a flow range overlapping applicant’s flow range as described in claims 9-10. Overlapping ranges are held obvious.

Claim Rejections - 35 USC § 103

1. Claims 6-8, 17-30, 33, 49-51, 53, 54, 55, 66, 70-72, 74-76 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Steinwandel et al. (US 5,782,085) and Raaijmakers et al. (US 5,460,689) as applied to the claims above, and further in view of Knipp (US 5,288,971).

The references of Sorensen et al. (US 2003/0129106), Selbrede et al. (US 2002/0020429), Steinwandel et al. (US 5,782,085) and Raaijmakers et al. (US 5,460,689) have been discussed above.

Selbrede discloses “the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.” (paragraph 0048), including in an NF3/ar mixture (paragraph 0070)(figure 12). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to increase pressure after plasma ignition because Selbrede teaches the power required to **ignite and sustain** a plasma in the Remote Plasma Chamber (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.

2. It is noted that Sorensen does not expressly disclose increasing the total pressure after ignition.

3. Knipp teaches “Ignition point (22) is a function of gas pressure, electrode spacing and size, and other chamber characteristics. The relationship between pressure and ignition voltage is referred to in the industry as a Paschen curve and is shown in FIG. 5. The Paschen voltage (14) decreases as pressure is decreased until it reaches a minimum value (13) which correlates to a certain pressure. Below this pressure, the Paschen voltage (14) again increases. Perhaps because the Paschen curve has been

well studied, solutions utilizing **pressure increases** as in U.S. Pat. No. 4,906,811 are often utilized." (column 5, line 12) .

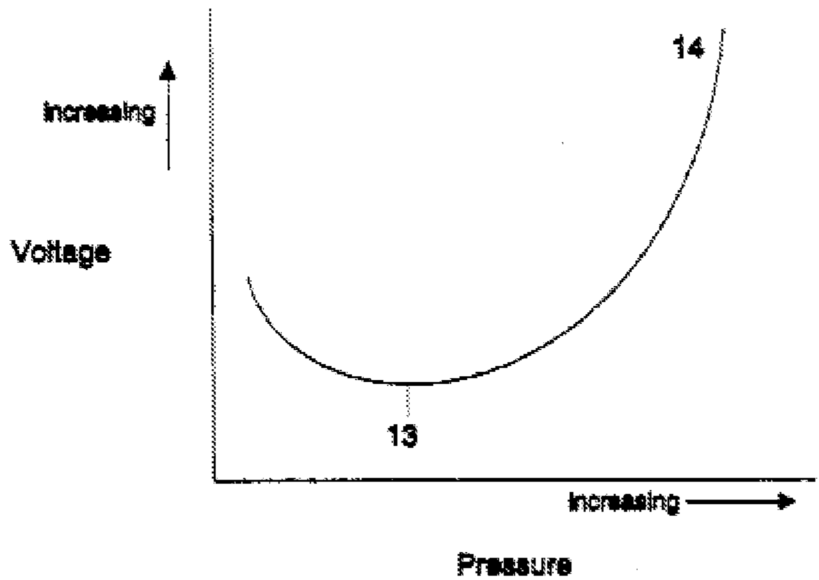

Figure 5

The reference of Knipp is not relied on to teach increasing pressure after plasma ignition, but Knipp is relied on to teach that, according to the Paschen curve, for every gas or gas mixture there is a minimum voltage for plasma ignition, this minimum depends on the pressure (and other parameters).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to perform plasma ignition at the pressure where the ignition voltage (power) is at minimum. One of

ordinary skill in the art would have been motivated to choose minimum voltage plasma ignition in order to obtain a reliable ignition process avoiding higher ignition voltages which can lead to arcing and damaging the high frequency voltage circuit. Then, if the desirable plasma process pressure is at the right hand side (14) of minimum voltage ignition point (13) in figure 5 of Knipp, it would have been obvious to one of ordinary skill in the art at the time the invention to increase the pressure from (13), after plasma ignition, to arrive at the desired process pressure (14).

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant's newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC's) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

As to claims 18-30 Sorensen discloses “For efficient operation, the internal pressure of the toroidal vessel 18 is held at a pressure suitable for the particular application. Typical pressures are in the range of 0.1 to 20 Torr. In some applications it may be desirable to maintain the pressure as high as feasible. In other words, the

pressure differential between the vessel 18 and the deposition chamber may be made as large as possible and may be at least, for example, 4.5 Torr. The pressure in the toroidal vessel 18 may be higher, for example, in the range of about 5 Torr to about 20 Torr, and in particular may be about 15 Torr. The pressure in the deposition chamber may be, for example, in the range of about 0.1 Torr to about 2 Torr, and in particular about 0.5 Torr. A flow restrictor 150 is employed to allow a high pressure plasma to be maintained without detrimentally affecting the pressure of deposition chamber 30. The flow restrictor 150 may be, for example, a small orifice or a series of small orifices, although any device that creates a pressure differential, such as a reduction valve or a needle valve, could be employed. The flow restrictor 150 may be placed at or near the point at which the pipe 140 enters deposition chamber 30." (paragraph 0044).

As to claim 33, Sorensen teaches, "Although the invention has been explained and illustrated in terms of embodiments that involved a PECVD system, the invention has far wider applicability. For example, the concept of a remote activation source (i.e., outside the main vacuum chamber), possibly used in conjunction with a local activation source (i.e., inside the main vacuum chamber) is useful in systems designed for the purposes of physical vapor deposition (PVD), chemical vapor deposition (CVD), ion doping, stripping of photoresist, substrate cleaning, **plasma etching**, and other purposes as well" (paragraph 0054). Sorensen clearly suggests using the same plasma generation apparatus for plasma etching application, NF3/Ar gas mixture is an etching gas mixture conventionally used for silicon substrate etching.

Claim Rejections - 35 USC § 103

3. Claims 11-12, 78, are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Steinwandel et al. (US 5,782,085), Raaijmakers et al. (US 5,460,689), and further in view of Ishikawa et al. (US 2002/0000198).

Sorensen discloses "For example, in a tungsten deposition system a fluorine compound gas is typically used to etch away tungsten deposited on the walls of the system to effect cleaning of those walls" (paragraph 052).

It is noted that Sorensen does not expressly disclose F2 as the fluorine compound gas. All other limitations have been addressed above in reference to Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), and Steinwandel et al. (US 5,782,085)

Ishikawa disclose "For the remote microwave cleaning system of FIG. 9 in the present invention, it is preferred to use NF.sub.3 and F.sub.2 diluted to concentrations of from about 10% to about 50% in inert argon gas. The desired cleaning reactions produced by the use of the remote plasma source proceed without any ion bombardment of the chamber or substrate support structures, therefor; the need for cover wafers on the ESC 104, or periodic replacement of critical chamber assemblies is avoided. Thus, a much more efficient use and throughput of the system is provided." (paragraph 0125). Ishikawa teaches mixed Ar/F2 gases are conventionally used for cleaning and are conventionally ignited to form plasmas.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include mixed Ar/F2 gases because Ishikawa teaches mixed Ar/F2 gases are conventionally used for cleaning and are conventionally ignited to form plasmas.

One of ordinary skill in the art would have been motivated to use mixed Ar/F2 gases when the nitrogen component in the plasma is not necessary for the effective cleaning of the chamber.

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant's newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC's) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

As to the ignition, pressure and flow conditions, as discussed above, in reference to claims 1-4, 6-8, 9-10, Sorensen and Ishikawa teach overlapping ranges for such parameters. Overlapping ranges are held obvious.

Claim Rejections - 35 USC § 103

4. Claims 31-32, 52, are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Steinwandel et al. (US 5,782,085) and Raaijmakers et al. (US 5,460,689) and in view of Ishikawa et al. (US 2002/0000198) and further in view of Knipp (US 5,288,971).

5. Selbrede discloses "the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma." (paragraph 0048), including in an NF3/ar mixture (paragraph 0070)(figure 12). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to increase pressure after plasma ignition because Selbrede teaches the power required to **ignite and sustain** a plasma in the Remote Plasma Chamber (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated, lowering the pressure within the RPC chamber 212 reduces the power required to sustain the plasma.

6. As discussed above Ishikawa teaches F2.

7. It is noted that Sorensen does not expressly disclose increasing the total pressure after ignition.

Knipp teaches "Ignition point (22) is a function of gas pressure, electrode spacing and size, and other chamber characteristics. The relationship between pressure and

ignition voltage is referred to in the industry as a Paschen curve and is shown in FIG. 5. The Paschen voltage (14) decreases as pressure is decreased until it reaches a minimum value (13) which correlates to a certain pressure. Below this pressure, the Paschen voltage (14) again increases. Perhaps because the Paschen curve has been well studied, solutions utilizing **pressure increases** as in U.S. Pat. No. 4,906,811 are often utilized." (column 5, line 12) . Selbrede clearly teaches lowering the pressure facilitates plasma ignition. Therefor, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to decrease the pressure in order to facilitate plasma ignition because Selbrede clearly teaches lowering the pressure facilitates plasma ignition, also, it would have been obvious to one of ordinary skill in the art at the time the invention was made to increase the pressure back to the processing pressure after the plasma has been ignited since Steinwandel teaches that reducing pressure for the purpose of plasma ignition is a known plasma ignition scheme. Steinwandel teaches "It is furthermore possible to superimpose **a brief** high-frequency pulse (with a pulse width of about 1 msec) on the stationary excitation field **or to reduce pressure** in order to ignite the plasma (breakdown)." (column 5, line 55). The reference of Steinwandel is not relied on to teach plasma jet processing, but it is relied on to teach that temporarily reducing pressure or temporarily increasing the excitation field are known methods for facilitating plasma ignition.

One of ordinary skill in the art would have been motivated to ignite the plasma at a lower pressure in order to facilitate plasma ignition as suggested by Steinwandel.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to increase a total pressure of said mixed gas, after plasma ignition has been facilitated with reduced pressure, by increasing the flow in said gas passage to a second pressure while maintaining said plasma, said cleaning step cleaning said interior of said processing vessel at said second pressure because Selbrede teaches the power required to **ignite and sustain** a plasma in the Remote Plasma Cleaning (RPC) chamber 212 is a function of the pressure of the gas from which the plasma is generated.

One of ordinary skill in the art would have been motivated to increase the total pressure of the gas mixture back to the preferred operating processing pressure, after plasma ignition, in order to obtain higher active cleaning species density due to higher pressure which also means higher molecular active density in the processing region.

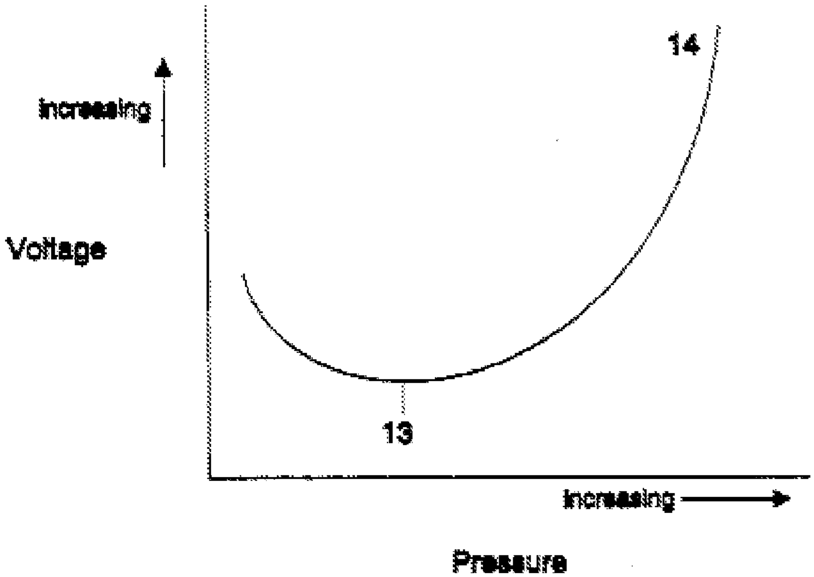

Figure 5

The reference of Knipp is not relied on to teach increasing pressure after plasma ignition, but Knipp is relied on to teach that, according to the Paschen curve, for every gas or gas mixture there is a minimum voltage for plasma ignition, this minimum depends on the pressure (and other parameters).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to perform plasma ignition at the pressure where the ignition voltage (power) is at minimum. One of ordinary skill in the art would have been motivated to choose minimum voltage plasma ignition in order to obtain a reliable ignition process avoiding higher ignition voltages

which can lead to arcing and damaging the high frequency voltage circuit. Then, if the desirable plasma process pressure is at the right hand side (14) of minimum voltage ignition point (13) in figure 5 of Knipp, it would have been obvious to one of ordinary skill in the art at the time the invention to increase the pressure from (13), after plasma ignition, to arrive at the desired process pressure (14).

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant's newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC's) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure

phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

Claim Rejections - 35 USC § 103

4. Claims 14-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Steinwandel et al. (US 5,782,085), Raaijmakers et al. (US 5,460,689), and Ishikawa et al. (US 2002/0000198) and further in view of Knipp (US 5,288,971).

5. It is noted that Sorensen does not expressly disclose increasing the total pressure after ignition.

6. Knipp teaches “Ignition point (22) is a function of gas pressure, electrode spacing and size, and other chamber characteristics. The relationship between pressure and ignition voltage is referred to in the industry as a Paschen curve and is shown in FIG. 5. The Paschen voltage (14) decreases as pressure is decreased until it reaches a minimum value (13) which correlates to a certain pressure. Below this pressure, the Paschen voltage (14) again increases. Perhaps because the Paschen curve has been well studied, solutions utilizing **pressure increases** as in U.S. Pat. No. 4,906,811 are often utilized.” (column 5, line 12) .

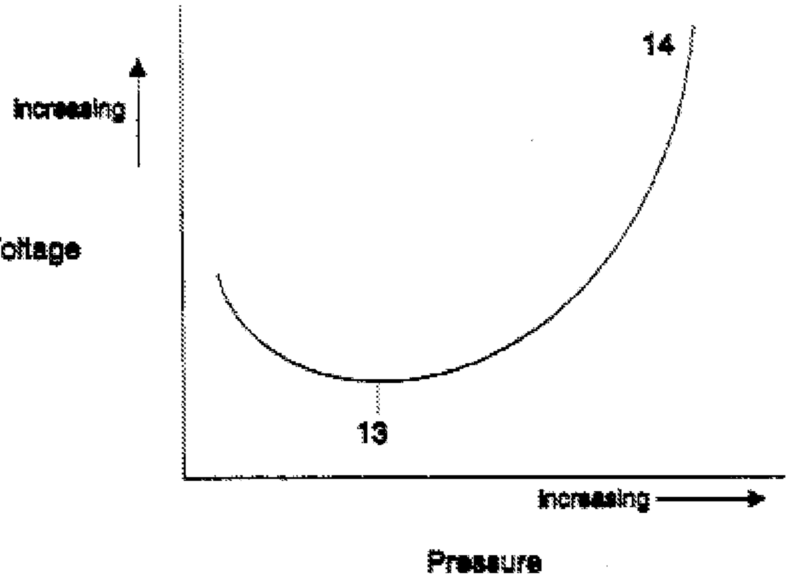

Figure 5

The reference of Knipp is not relied on to teach increasing pressure after plasma ignition, but Knipp is relied on to teach that, according to the Paschen curve, for every gas or gas mixture there is a minimum voltage for plasma ignition, this minimum depends on the pressure (and other parameters).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to perform plasma ignition at the pressure where the ignition voltage (power) is at minimum. One of ordinary skill in the art would have been motivated to choose minimum voltage plasma ignition in order to obtain a reliable ignition process avoiding higher ignition voltages

which can lead to arcing and damaging the high frequency voltage circuit. Then, if the desirable plasma process pressure is at the right hand side (14) of minimum voltage ignition point (13) in figure 5 of Knipp, it would have been obvious to one of ordinary skill in the art at the time the invention to increase the pressure from (13), after plasma ignition, to arrive at the desired process pressure (14). The the gas flows have been discussed above in reference to claims 9-10.

Claim Rejections - 35 USC § 103

Claims 34-46, 56-62, are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Raaijmakers et al. (US 5,460,689), Steinwandel et al. (US 5,782,085) and further in view of Motley et al. (US 4,662,977) and Knipp (US 5,288,971).

Regarding claims 56-62 It is noted that Sorensen does not expressly disclose the gas flows and conductances as required by the claims, however, the references of Sorensen and Selbrede have been discussed above, Sorensen teaches, “Although the invention has been explained and illustrated in terms of embodiments that involved a PECVD system, the invention has far wider applicability. For example, the concept of a remote activation source (i.e., outside the main vacuum chamber), possibly used in conjunction with a local activation source (i.e., inside the main vacuum chamber) is useful in systems designed for the purposes of physical vapor deposition (PVD), chemical vapor deposition (CVD), ion doping, stripping of photoresist, substrate cleaning, **plasma etching**, and other purposes as well” (paragraph 0054). Sorensen

clearly suggests using the same plasma generation apparatus for plasma etching application, NF3/Ar gas mixture is an etching gas mixture conventionally used for silicon substrate etching as evidenced by Motley who teaches, in a downstream etching system, “To etch silicon nitride the admitted gas would comprise 85% CF.sub.4 or C.sub.2 F.sub.6, and the balance 10% **argon** and 5% oxygen: or for higher species **NF.sub.3** or SF.sub.6 may be substituted for CF.sub.4 or C.sub.2 F.sub.6.” (column 4, line 48) . Overlapping ranges are held obvious.

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant’s newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC’s) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

As to claims 34-40, Sorensen discloses “An electronically operated valve and flow control mechanism 54 controls the flow of gases from the gas supply 52 into the chamber 30. Also connected to the chamber 30 through an outlet port is a vacuum

pump 56, which is used to evacuate the chamber and maintain a suitable vacuum pressure inside the chamber 30." (paragraph 0030). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the pressure by controlling the gas flow and/or the pumping speed because gas flow represent the rate at which gas molecules are introduced into the system and pumping speed represent the rate at which gas molecules are evacuated from the system. One of ordinary skill in the art would have been motivated to control the gas pressure by controlling gas input and/or gas output to the system since gas flow meters and pumping throttle (control) valves are provided in any etching system, and are the most effective pressure control parameters. As to choosing the specific control scheme, one who is skilled in the art would be motivated to optimize through routine experimentation the proper pressure control scheme depending on the desired results. It has been held that the provision of adjustability, where needed, involves only routine skill in the art.

It is also noted that Sorensen is silent about switching between two mass flow controllers when the total pressure is increased as required in applicant's newly amended claims.

Raaijmakers discloses a method of plasma processing wafers wherein are described the steps of placing the wafer in a plasma chamber; flowing a gas into the plasma chamber; establishing a plasma in the chamber at a first pressure; after establishing the plasma, plasma etching the wafer at the first pressure for a first period of time; transitioning to a second pressure that is different from the first pressure; plasma etching the wafer at the second pressure for a second period of time; and after

the second period of time has elapsed, discontinuing plasma etching at the second pressure (abstract). The reference of Raaijmakers is not relied on to teach the said plasma treatment, but it is relied on to teach that 2 mass flow controllers (MFC's) are conventionally used when a wide range of processing pressures is required during plasma processing.

Raaijmakers discloses a first mass flow controller for controlling the flow of a gas into the chamber during a low pressure phase of plasma etching; and a second mass flow controller for controlling the flow of the gas into the chamber during a high pressure phase of plasma etching, the first mass flow controller rated at a higher flow rate than the second mass flow controller.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity, said step of switching said mass flow controller being conducted while maintaining said plasma because Raaijmakers suggests such a practice.

One of ordinary skill in the art would have been motivated to include a dual MFC system including the step of switching a mass flow controller used to supply said NF3 gas from a first mass flow controller having a first capacity to a second mass flow controller having a second capacity larger than said first capacity in order to maintain

accuracy of the gas flow at low pressure as well as high pressure when one MFC cannot accurately cover the whole rage of processing pressures.

As to claim 41, as discussed above, Clearly Sorensen suggests NF3 without argon is harder to ignite than an Ar/NF3 gas mixture. In addition Selbrede teaches Ar/NF3 gas flow ratio are conventionally known to be variable process parameter varying essentially from 0% to 100%.

As to claims 43-46, flow rates and pressure for ignition have been discussed above in reference to claims 1-10.

Claim Rejections - 35 USC § 103

7. Claims 47-48, 73, are rejected under 35 U.S.C. 103(a) as being unpatentable over Sorensen et al. (US 2003/0129106) in view of Selbrede et al. (US 2002/0020429), Raaijmakers et al. (US 5,460,689), and in view of Motley et al. (US 4,662,977) and Knipp (US 5,288,971).and further in view of of Ishikawa et al. (US 2002/0000198).

Sorensen discloses "For example, in a tungsten deposition system a <u>fluorine compound gas</u> is typically used to etch away tungsten deposited on the walls of the system to effect cleaning of those walls" (paragraph 052).

It is noted that Sorensen does not expressly disclose F2 as the fluorine compound gas.

Ishikawa disclose "For the remote microwave cleaning system of FIG. 9 in the present invention, it is preferred to use NF.sub.3 and F.sub.2 diluted to concentrations

of from about 10% to about 50% in inert argon gas. The desired cleaning reactions produced by the use of the remote plasma source proceed without any ion bombardment of the chamber or substrate support structures, therefor; the need for cover wafers on the ESC 104, or periodic replacement of critical chamber assemblies is avoided. Thus, a much more efficient use and throughput of the system is provided." (paragraph 0125). Ishikawa teaches mixed Ar/F2 gases are conventionally used for cleaning and are conventionally ignited to form plasmas.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Sorensen to include mixed Ar/F2 gases because Ishikawa teaches mixed Ar/F2 gases are conventionally used for cleaning and are conventionally ignited to form plasmas.

One of ordinary skill in the art would have been motivated to use mixed Ar/F2 gases when the nitrogen component in the plasma is not necessary for the effective cleaning of the chamber.

Response to Arguments

Applicant's arguments, filed 3/4/2009, with respect to the rejection(s) of all pending claim(s) under 35 USC § 103 have been fully considered and are persuasive in view of the newly added amendments to independent claims. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Raaijmakers et al. (US 5,460,689).

.Any inquiry concerning this communication or earlier communications from the examiner should be directed to MAHMOUD DAHIMENE whose telephone number is (571)272-2410. The examiner can normally be reached on week days from 8:00 AM. to 5:00 PM..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/M. D./
Examiner, Art Unit 1792

/Nadine G Norton/

Supervisory Patent Examiner, Art Unit 1792